

## SPECIFICATION

## TITLE

METHOD AND ARRANGEMENT FOR OPTIMIZING AN AMPLITUDE-MODULATED  
OPTICAL SIGNAL

## 5 BACKGROUND OF THE INVENTION

## FIELD OF THE INVENTION

[0001] The invention relates to a method and arrangement  
for optimizing an amplitude-modulated optical signal.

## DESCRIPTION OF THE RELATED ART

10 [0002] Digital signals are frequently transmitted in  
optical networks with the aid of amplitude modulation (ASK).  
A carrier wave is transmitted in the case of one logic  
state, and no signal/carrier wave is transmitted during the  
other logic state. Early in the modulation (on-off), a  
15 "chirp" is produced which changes the wavelength and  
amplitude of the output signal. The transient component of  
the chirp causes large variations in the edge regions, and a  
sharp increase or decrease in the wavelength; the switch-on  
edge is of particular importance since the changes occur in  
20 the case of a full signal level. The other adiabatic  
component of the chirp can be kept small by a suitable  
design of the modulator.

[0003] During transmission of a pulse in a waveguide  
(glass fiber), self-phase modulation of the carrier occurs  
25 (this being a further form of the chirp) in which the  
wavelength changes likewise, particularly in the leading  
edge region and trailing edge region of the pulse. Also,  
amplitude distortions can occur.

[0004] The two wavelength distortions, including the  
30 transient component of the chirp induced by switching on,  
and the self-phase modulation result in pulse distortion of  
the baseband signal, contribute (particularly in the case of  
transmission systems with high bit rates) to limiting the  
data rate and the transmission range.

[0005] An attempt is usually made to minimize the chirp-induced disturbing influences by setting operating points of Mach-Zehnder modulators or integrated electro-absorption modulators in a test bay. However, resettings must be undertaken when changes occur to the operating parameters.

[0006] British patent document GB 2 308 675 A discloses an arrangement and a method for driving an optical modulator and describes the setting of a chirp parameter where monitoring the modulated signal is performed at the receiving end in order to set the chirp parameters via a back channel for pulse compression.

[0007] British patent document GB 2 316 821 A describes an optical time-division multiplex system which compensates the chromatic dispersion of the transmission path by means of controlled chirping of the transmitted signal. Monitoring of the modulated signal is not provided.

[0008] Earlier European patent application EP 0 971 493 A1 likewise describes a method for compensating dispersion and nonlinearities in optical communication systems. In this system, however, it is, for example, the error rate which is measured and the transmission level which is controlled as parameters. Both measures do not appear to be expedient in modern optical systems.

#### SUMMARY OF THE INVENTION

[0009] It is therefore the object of the invention to provide a method and an arrangement for permanent optimization of the pulse shape/spectral distribution of an amplitude-modulated optical signal, particularly taking into account the modulation-induced chirp and the self-phase modulation in optical transmission systems.

[0010] Achievements of this object are specified in the independent claims. Advantageous developments of the invention are specified in the subclaims.

[0011] This object is achieved by a method for optimizing an amplitude-modulated optical signal, comprising the steps of generating the amplitude-modulated optical signal in a modulator by modulating an optical signal with a digital  
5 signal; feeding the amplitude-modulated optical signal to a frequency discriminator which outputs a spectral distribution signal; feeding the spectral distribution signal to a control device which is also fed an adjustable reference signal; and generating a control signal which sets  
10 an operating point of the modulator by comparing the adjustable reference signal and the spectral distribution signal. The inventive method may further comprise the step of separating a measuring signal which is fed to the frequency discriminator from the amplitude-modulated optical  
15 signal. The method may further comprise the steps of determining the spectral distribution signal at a start of a transmission path; and setting the reference signal based on properties of the transmission path. The method may further comprise the steps of determining the spectral distribution  
20 signal at a receiving end; and transmitting the spectral distribution signal or a control signal generated therefrom to the modulator provided at a transmitting end. The control signal may be obtained during periodically occurring time windows.

[0012] This object is also achieved by an arrangement for optimizing an amplitude-modulated optical signal, comprising a light source; a modulator having an output, the modulator being fed an optical signal from the light source and a digital signal for amplitude modulation; a frequency  
30 discriminator which outputs a spectral distribution signal that is connected to the output of the modulator via a splitter; and a control device with a reference signal setting device which is fed the spectral distribution signal and which generates a control signal which controls an  
35 operating point of the modulator. The arrangement may further comprise an adder which is fed the control signal

and the digital signal, an adder output being fed to a modulation input of the modulator.

[0013] The measures according to the invention consist of using quality criteria for optimal modulation of the optical  
5 signal to set the operating point of the modulator and maintaining the optimum setting by way of a control loop.

[0014] An advantageous and simple solution is to derive a measuring signal from the modulated optical digital signal and feed it to a frequency discriminator. The output signal  
10 of the frequency discriminator is transmitted via a control device which determines the operating point of the modulator.

[0015] If the measuring signal is tapped at the receiving end, the properties of the transmission path can be taken  
15 into account via an adjustable reference signal. The output signal of the modulator is set so as to produce an optimal received signal.

[0016] If a back channel (as a rule, a service channel) is available, a measuring signal can be tapped from the  
20 baseband signal and evaluated. The spectral distribution signal output by a phase discriminator, or a control signal generated therefrom, will be transmitted to the source of the signal, i.e., the modulator.

#### BRIEF DESCRIPTION OF THE DRAWING

25 [0017] The invention is explained in more detail with the aid of an exemplary embodiment. The Figure is a schematic block diagram showing a first exemplary embodiment with spectral appraisal.

#### DETAILED DESCRIPTION OF THE INVENTION

30 [0018] The Figure shows a first exemplary embodiment of a control loop for optimizing the modulation-induced chirp. The block diagram shows only the modules essential to the invention. A laser provided as a narrow-band light source 1 supplies an optical signal OS of high frequency, which is

fed to a modulator 2. The optical signal is subjected to amplitude modulation by way of a digital signal DS (on-off keying). The modulated optical signal OSM, output by the modulator, is fed into an optical conductor of a

5 transmission path 3 and transmitted. A measuring signal OMT of low power is tapped from the modulated signal via a splitter (coupler) 4 and fed to a frequency discriminator 5. The frequency discriminator can include, for example, an optical filter whose edge, which is as rectilinear as  
10 possible, is used for frequency demodulation.

[0019] The demodulated optical signal is converted into an electric spectral distribution signal SV and fed to a control device 6. The spectral distribution signal SV is fed as a reference input; an adjustable reference signal RS is  
15 generated via a reference setting device 7 (a voltage divider in the example). The control device supplies as a manipulated variable a control signal SR which sets the operating point of the modulator and thereby optimizes the transient chirp of the modulated optical signal even in the  
20 case of changes in the component properties.

[0020] An optimum setting is given when the receive signal is optimal. A measurement at the receiving end is actually required for this purpose. However, a compact replacement transmission path used for the setting likewise  
25 permits an exact setting. The spectral distribution signal serves as a criterion during setting. A specific envelope of the modulated signal corresponds to this criterion, and can likewise serve as a criterion.

[0021] If the properties of the transmission path are  
30 known, they are already taken into account during setting, and the spectral distribution (or a pulse shape) is set so as to produce optimal receiving conditions.

[0022] Since the spectral distribution signal SV can be weakly dependent on the bit sequence of the digital signal,  
35 it can be expedient to have a time window ZF during which

specific bit sequences are transmitted and the control signal is determined.

5 [0023] The control signal RS and the digital signal can be combined by an adder, and the aggregate signal is then fed to the modulation input of the modulator.

10 [0024] As in the arrangement illustrated in Figure 1, it is also possible, of course, to appraise the spectral distribution of a modulated optical signal at the receiving end, and a corresponding spectral distribution signal or else the control signal derived therefrom may be provided to the transmitting part.

15 [0025] The above-described method and apparatus are illustrative of the principles of the present invention. Numerous modifications and adaptations will be readily apparent to those skilled in this art without departing from the spirit and scope of the present invention.

# LIST OF REFERENCE SYMBOLS

	DS	Digital signal
	DD	Demodulated digital signal
	1	Laser
5	2	Modulator
	3	Optical conductor
	4	Splitter
	5	Discriminator
	6	Control device
10	7	Reference setting device
	RS	Reference signal
	OS	Optical signal
	OSM	Amplitude-modulated optical signal
	OMT	Measuring signal
15	SV	Spectral distribution signal
	SF	Control signal
	ZF	Time window
	8	Summing device
	9	Receiving device
20	10	Optoelectric transducer
	11	Amplifier
	12	Decision circuit
	13	Data output
	14	Measuring instrument appraising device
25	15	Evaluation device
	16	Controller
	17	Modulation input
	18	Transmitting device
	19	Receiving device
30	SE	Setting signal